Heaven's Light is Our Guide

Rajshahi University of Engineering & Technology

Department of Electrical & Computer Engineering

Course No: ECE 4124

Course Title: Digital Signal Processing Sessional

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Experiment Name: Experiment on finding the Z-transform and inverse Z-transform of a

- a MATLAB code of right sided signal
- a MATLAB code of left sided signal
- a MATLAB code of Non-Causal Signal
- Plotting poles and zeros on the Z plane for above signals

Theory:

Z-Transform: The Z-transform is a mathematical transformation that converts a discrete-time signal, which is a sequence of values indexed by integers, into a complex function of a complex variable Z. The Z-transform of a sequence x[n] is defined as:

X(Z) = Σ (x[n] * Z^(-n)), where the summation is taken over all integer values of n.

In simpler terms, the Z-transform provides a way to represent a discrete-time signal in the Z-domain, where Z is a complex variable. This domain is useful for analyzing the frequency characteristics and properties of discrete-time signals and systems.

Inverse Z-Transform:

The **inverse Z-transform** is used to convert a function in the Z-domain back to the time-domain representation. The general form of the inverse Z-transform is given by:

x[n] = (1/2πj) ∮ X(Z) * Z^(n-1) dZ

where x[n] is the sequence in the time domain, X(Z) is the Z-transform of the sequence, and the integral is taken around a closed contour in the complex Z-plane.

Right Sided Signal: A right-sided signal in the context of the Z-transform is a sequence that is nonzero only for nonnegative indices or time instances. The definition of the Z-transform can be used to compute the Z-transform of a right-sided signal.

The general formula for the Z-transform of a right-sided signal x[n] is:

X(z) = [x[n] * z(-n)], with n ranging from 0 to infinity.

Left Sided Signal: Z-transform, a right-sided signal is a sequence that is nonzero only for nonnegative indices or time instances. The Z-transform of a right-sided signal can be computed using the definition of the Z-transform.

The general formula for the Z-transform of a right-sided signal x[n] is:

X(z) = ∑[x[n] * z^(-n)], for n = 0 to infinity

Causal and Anti causal Signal: In the context of the Z-transform, a causal signal refers to a sequence that is nonzero only for nonnegative indices or time instances. On the other hand, an anti-causal signal refers to a sequence that is nonzero only for negative indices or time instances.

Non-Causal Signal: non-causal signal in the context of the Z-transform refers to a sequence that has nonzero values for both positive and negative indices or time instances. The Z-transform of a non-causal signal can still be computed using the definition of the Z-transform.

The general formula for the Z-transform of a non-causal signal x[n] is:

$$X(z) = \sum[x[n] * z^{(-n)}], \text{ for all values of n}$$

Code & Output:

Right sided signal (Causal):

```
x=[1 2 3 4 5]
b=0;
n=length(x);
y=sym('z');
for i=1:n
    b=b+x(i)*y^(1-i);
end
display(b)

z=[];
p=[0]
zplane(z,p)
```

Output:

```
>> z_transform

x =

     1     2     3     4     5


b =

2/z + 3/z^2 + 4/z^3 + 5/z^4 + 1
```

Figure 5.1: Right Sided Signal

Zeros and poles:

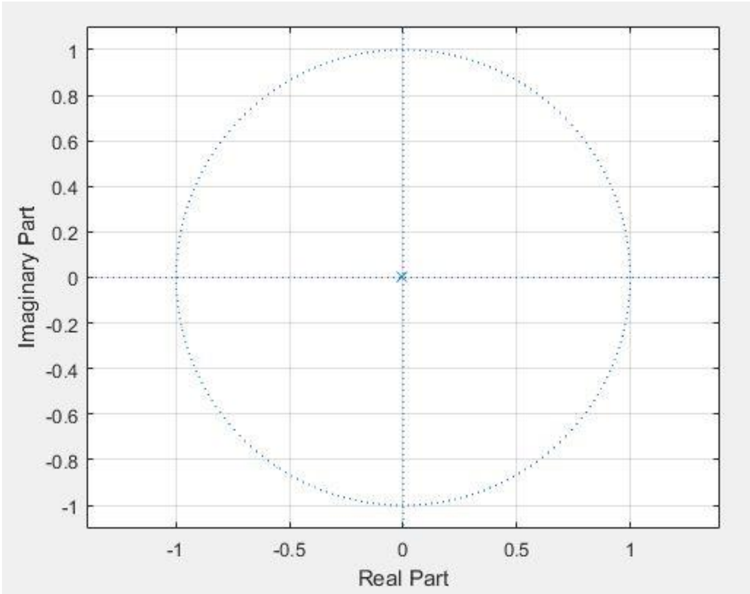

Figure 5.2: Zeros and Poles

Left sided signal (Anti Causal):

```
x=[1 2 3 4 5]
b=0;
n=length(x);
y=sym('z');
for i=1:n
    b=b+x(i)*y^(i-1);
end
display(b)
z=[];
p=[]
zplane(z,p)
```

Output:

```
x =

     1     2     3     4     5


b =

5*z^4 + 4*z^3 + 3*z^2 + 2*z + 1
```

Figure 5.3: Left Sided Signal

Poles and Zeros:

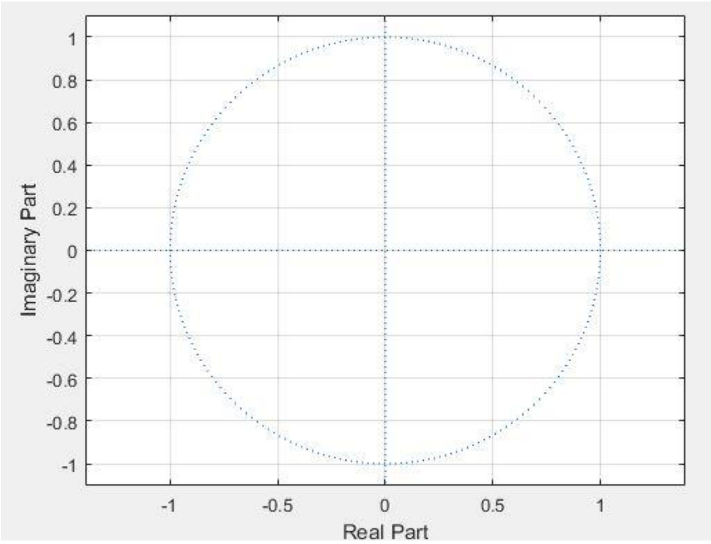

Figure 5.4: Zeros and Poles

Code of non causal signal:

```
x=[1 2 3 4 5]
value=3;
index=find(x==value);
disp(index);


b=0;
n=length(x);
y=sym('z');
for i=1:n
    b=b+x(i)*y^(index-i);
end
display(b)


z=[];
p=[0]
zplane(z,p)
grid
```

Output:

```
x =

     1     2     3     4     5

     3


b =

2*z + 4/z + 5/z^2 + z^2 + 3
```

Figure 5.3: Non causal signal

Poles and Zeros:

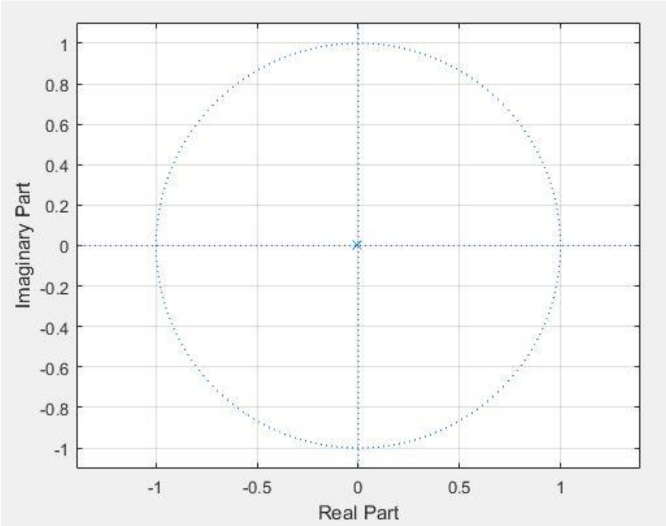

Figure 5.4: Poles and Zeros

Discussion: In this experiment, we discovered several types of signals, including causal, anti-causal, and non-causal signals. We could see these signals' fundamental variations. A causal signal is a sequence that is nonzero only for nonnegative indices or time instances. The Z-transform of a causal signal is typically a rational function with a region of convergence (ROC) that includes the unit circle. An anti-causal signal is a sequence that is nonzero only for negative indices or time instances. The Z-transform of an anti-causal signal is typically a rational function with a region of convergence (ROC) that includes the exterior of the unit circle. A non-causal signal is a sequence that has nonzero values for both positive and negative indices or time instances.

Conclusion: We successfully completed the task as we got the exactly same result which we learnt from the theory.